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Insect visits to some bamboos of the Western Ghats, India

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Bee visits in six tropical woody bamboos (Bambusoideae: Poaceae) – *Bambusa bambos* (native), *Bambusa* sp., *B. vulgaris* (both cultivated), *Ochlandra ebracteata*, *O. scriptoria*, *O. travancorica* (all endemic) were studied. The bees were predominantly of order Hymenoptera and belong to genera *Apis*, *Halictus*, *Trigona*, *Braunsapis* and *Ceratina*. In *Ochlandra* spp and *B. vulgaris* the bees visited the florets only at the male stage. In *B. bambos* and *Bambusa* sp., the florets are wide opened and the male and female organs are exposed together. It is presumed that pollination by bees can occur in such species. Grouping of spikelets based on nature of opening of florets is also discussed.

GRASSES are traditionally considered as wind-pollinated (anemophilous). The peculiar floral features such as reduction of petals into lodicules, absence of nectaries, many flowered inflorescences, large anthers producing abundant uniform pollen grains with smooth exine, thick intine, small germ pore and fewer number of ovules are factors facilitating anemophily[1]. These factors are often interpreted as adaptations for wind pollination to increase efficiency[2]. Knuth[3], who studied insect visits to grasses in detail, attributed such visits to the pursuit of food such as pollen or sweet secretions and explicitly stated that all species of grasses are distinctly anemophilous. Some of the later workers[4–6], on the contrary, have shown that entomophily does occur at least in a few grass species. In the pioneering study by Soderstrom and Calderon[1] on two South American understorey bambusoid grass genera *Olyra* and *Pariana*, insect pollination was suspected.

In woody bamboos, insect visits were reported in a few species such as *Bambusa polymorpha*[7], *Gigantochloa albociliata*[8], *Bambusa vulgaris* var. *vittata*[9], etc. *Apis* and *Trigona* bees were observed removing pollen from *Schizostachyum zollingeri*[10–12], *Apis mellifera* and *Allodape marginata* from the dichogamous *Ochlandra travancorica*[13] and *Dendrocalamus strictus*[14] during the male phase, as well as *Trigona biroi Friese* and *Halictus* sp. from *Bambusa vulgaris*[15]. In this communication, observations on floral biology and bee visitation during the reproductive phase of six woody bamboo species, viz. *Bambusa bambos* (L.) Voss, *B. vulgaris* Schrad. ex Wendl., *Bambusa* sp. (indetermined), *Ochlandra ebracteata* Raizada & Chatterji, *O. scriptoria* C. E. C. Fischer and *O. travancorica* (Bedd.) Benth., belonging to the tribe *Bambuseae* under the subfamily Bambusoideae of the family Poaceae are presented. Of the six taxa *B. bambos* is native, from India to China, *B. vulgaris* and *Bambusa* sp. are cultivated, while the three *Ochlandra* spp are endemic to the Western Ghats[16].

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Six species of bamboos were available for study in the flowering phase from 1994 to 2000. *O. travancorica, O. scriptoria and Bambusa* sp. flowered during 1998–2000, 1994–1998 and 1995–1998, respectively, in the bambusetum[17] of the Tropical Botanic Garden and Research Institute (TBGRI), Thiruvananthapuram situated at the southern-most part of India (8°45′328″N, 77°01′486″E). *O. ebracteata* flowered during 1999–2000 in Achencoil Forest Division (9°4′177″N, 77°10′764″E), *B. bambos* during 1997–1999 in Chelampra (11°09′799′N, 75°52′559″E), Malappuram district and *B. vulgaris* during 1996–1999 in Cherthala (9°40′453″N, 76°20′120″E) in Alappuzha district, Kerala. Since all these species attain more than 6 m in height, two to three flowering culms of the respective clumps were bent horizontally and tied, to fix them at breast height for convenience of observation. Portion of inflorescence of 1 m length where active development of spikelets occurred was marked and observations on floret opening and insect activity were carried out. Observations were also made on offsets of those species which flowered outside TBGRI and collected from the location of their flowering and grown in the bambusetum. The atmospheric temperature and relative humidity at the site of flowering clumps were recorded using a thermohygrometer (model HI 8564). The exposure of the tip of emerging anthers from a floret (peeping-out stage) was considered as a sign of opening of florets and their numbers were counted. To quantify bee visitation, the number of bees that actually rested on opened florets was counted. All observations were recorded at regular intervals of 30 min from 6 am to 6 pm and repeated three to five times at weekly intervals. To calculate the duration of opening and closing of florets, about-to-open turgid florets were spotted using a marker pen. Ten to fifteen florets thus marked each day were continuously observed to record the time taken from the unopened stage of floret to the maximum widening of lemma and palea and then to their reclosing. The insects were photographed with a Nikon F3 camera using Micro-Nikor 105 mm lens and Konica film (100 ASA). The insects were trapped and preserved in 70% ethyl alcohol. They were later curated as described by Noyes[18]. Laboratory observations were made using M3Z Wild Stereozoom and Leitz–Watzlar microscopes. The insect specimens were deposited at Zoology Department, Calicut University, since the centre specializes in the taxonomy of Hymenoptera. The voucher specimens of bamboos on which the insects visited were gathered[19], processed and deposited in TBGT.

Details of the bee collections from three *Ochlandra* spp and three *Bambusa* spp are presented in Table 1. The common species found visiting the flowers are of the genera *Apis* and *Halictus* followed by *Trigona, Braunsapis*

Table 1. Bamboo and bee collections

Bamboo collection		Bee collection			
Genus and species	Collection number	Order	Family	Genus and species	Collection number
Ochlandra ebracteata Raizada & Chatterji	34268	Hymenoptera	Apidae: Apinae	*Apis cerana* Fabricius	34268-01
			Anthophoridae: Xylocopinae: Ceratinii	*Ceratina heiroglyphica* Smith	34268-02a
			Anthophoridae: Xylocopinae: Allodapinii	*Braunsapis mixta* Smith	34268-02b
		Diptera	Calliphoridae	–	34268-03
		Hymenoptera	Halictidae	*Halictus* sp. I	34268-04, 05
Ochlandra scriptoria C.E.C. Fischer	30304	Hymenoptera	Apidae: Apinae	*Apis cerana* Fabricius	*s. n.*
Ochlandra travancorica (Bedd.) Benth.	34261 (281)	Hymenoptera	Apidae: Apinae	*Apis dorsata* Fabricius	281-01
			Apidae: Apinae	*Apis cerana* Fabricius	281-02
			Apide: Meliponinae	*Trigona biroi* Friese	281-05
			Anthophoridae: Xylocopinae	*Braunsapis picitarsis* Cameron	281-04a, 06
			Halictidae	*Halictus proteus* Vachal	281-04b
				Halictus sp. II	281-03
Bambusa bambos (L.) Voss	30394	Hymenoptera	Apidae: Apinae	*Apis cerana* Fabricius	*s. n.*
			Halictidae	*Halictus* sp.	*s. n.*
Bambusa sp.	26727	Hymenoptera	Apidae: Apinae	*Apis cerana* Fabricius	*s. n.*
			Halictidae	*Halictus* sp.	*s. n.*
Bambusa vulgaris Schrad. ex Wendl.	30348, 34285	Hymenoptera	Apidae: Meliponinae	*Trigona biroi* Friese	*s. n.*
			Halictidae	*Halictus* sp. III	34285-01

One species belonging to the family Calliphoridae of order Diptera (34268-03) found on *O. ebracteata* is yet to be identified.

and rarely *Ceratina*. The larger bee *Apis dorsata* was seen preferentially visiting *Ochlandra* (*travancorica*), whereas smaller bees do not exhibit such a preference. In all the species, the bees usually land on anthers and break the anther lobes by mouth appendage and front legs to collect pollen grains. While collecting pollen grains, the hind metasomal part moves in a peculiar drumming manner and strikes the anther lobes along with the fluttering of wings, together producing a humming sound. This humming sound can be heard from a distance of 12–15 m away from the plant, especially during visitation by *A. dorsata* and *A. cerana*. In all bamboo species studied it has been observed that after visiting one floret the bees visited the anthers of another floret. Data on floral opening and bee visitation are provided in Tables 2 and 3. Since the mean values are calculated from weekly readings, greater range of variation (cf. standard deviation) occurred, which can be attributed to change in weather conditions and flowering phenology of individual clumps.

In the genus *Ochlandra*, the spikelets are dichogamous and one-flowered, with 18 (*O. scriptoria*) to 120 (*O. travancorica*) stamens. The anthers are yellowish or slightly brownish-yellow, which when exserted form a showy brush-like tassel (Figure 1 *a*, *c*, *d*). During opening of the floret the tip of the flowering glumes widen 3–4 mm apart, forming an angle of 8° between lemma and palea for the emerging anthers to come out (Figures 1 *a*, *c* and 2 *b*). Once they are exserted, the lemma and palea close back (Figure 1 *d*). The floral opening in *Ochlandra* spp started from 6.30 am and extended up to 12 noon, when atmospheric temperature ranged between 20 and 32°C. Maximum opening was noticed between 8.30 am and 11 am. Bee visitation started by 6.30 am and extended up to 12 noon, with a maximum between 8.30 am and 11 am (Table 2). Bee activity was noticed just from the peeping-out stage of the anthers. During the activity severe competition (Figure 1 *a*) among bees was also noticed, which caused serious injury to the florets. The bees 'damaged' 50–80 stamens in a spikelet within 5–8 min, each bee spending up to 2 min in a spikelet. This destructive foraging of bees on immature anthers prevented normal dehiscence and dispersal of pollen grains. No bee activity was noticed during the female stage of the spikelet.

In all species of *Bambusa* studied, the spikelets consist of 5–8 florets (Figure 1 *b*, *e–g*). The florets are homogamous, consisting of 6 stamens. The anthers are yellow in *B. bambos,* yellow or brownish-yellow in *Bambusa* sp. and maroon in *B. vulgaris*. During floral opening the lemma and palea of *B. bambos* and *Bambusa* sp. widen 5–7 mm apart, forming an angle of 43–49° thus exposing the stigma and stamens, and close back after pollination (Figures 1 *b*, *e*, *f*, and 2 *d*, *e*). However, in *B. vulgaris* during floral opening, the lemma and palea widen only 1.5–2 mm (ref. 20), forming an angle of 8 to 9° (Figures 1 *g* and 2 *f*) just to make room for the anthers to emerge out and close back immediately after exsertion. As a result, the style and stigma are usually not exposed. Therefore, in the former two species since the florets are wide opened, the bees can enter them and can access the stigmatic lobes, while in *B. vulgaris* they have no access to the stigmas.

In *B. bambos*, the opening of florets to anther dehiscence took 2.5 to 3 h and anther dehiscence to re-closing took 3 to 3.5 h. The florets remained open for 5.5 to 6.5 h. Floret opening and bee visitation started by 6.30 am and extended up to 12 noon, when the temperature was between 23 and 29°C and relative humidity was 47–68 per cent. The maximum number of florets found opened and maximum bee activity were observed between 7 am and 8.30 am (Table 3), when temperature was 24–26°C and relative humidity was 59–68 per cent. In *B. vulgaris*, opening of florets started by 6.30 am and continued up to 10.30 am. The maximum number of florets opened and maximum bee activity were observed between 7 am and 8 am (Table 3), when temperature was 24–26°C and relative humidity was 81–87 per cent.

In *Bambusa* sp., floret opening to anther dehiscence took 2 to 2.5 h and the lemma and palea closed back 2.5 to 3 h after anthesis. Thus the florets were opened for 4.5 to 5.5 h. Unlike in other species, curiously, the floret opening started at 6.30 am and extended up to 6 pm with a gap between 1 pm and 2.30 pm during which no opening of the floret was noticed. Bee visitation was observed twice daily from 7 am to 12 noon and 3.30 pm to 6 pm. Floret opening and bee visits were maximum from 8.30 am to 10.30 am and 4 pm to 5 pm (Table 3), when the temperature was between 24 and 31°C.

During visitation to *Bambusa* spp, the bees rested on anthers (Figure 1 *b*, *e–g*) for 30 to 60 s. Compared with *Ochlandra,* the number of bees visiting per floret was lower in *Bambusa* (Tables 2 and 3).

Though the bees *Apis mellifera* and *Allodape marginata* are known to visit the spikelets of *O. travancorica*[13], we did not observe them during our studies, but collected six other species.

The greater number of species of bees recorded in *Ochlandra* spp could be attributed to the greater unit area of anthers available for foraging in comparison with *Bambusa* spp. There exists a relation between opening of florets and visit of bees (Tables 2 and 3). The time of maximum bee activity corresponds with the time of optimum floral opening.

In the six bamboo species studied, the role of bees in pollination could not be proved. In *Ochlandra* where there is a long gap between the maturation of the male and female phases, the bees visited the florets only in the male stage. In *B. vulgaris*, the florets though monogamous are functionally males[15] and the stigmas are inaccessible to bees. In *B. bambos* and *Bambusa* sp. where the floral glumes are pushed wide apart during opening, the appendages of bees are accessible to the feathery stigmas. It is also to be noted that, in all the three *Bambusa* species studied, the stamens are longer than the pistils and they

Table 2. Floret opening and bee visitation in *Ochlandra*

Time	*Ochlandra ebracteata* February–March 1999				*Ochlandra scriptoria* March–April 1996				*Ochlandra travancorica* February–March 1999			
	Temperature °C	Relative humidity %	No. of florets opened	No. of bees visited/floret	Temperature °C	Relative humidity %	No. of florets opened	No. of bees visited/floret	Temperature °C	Relative humidity %	No. of florets opened	No. of bees visited/floret
6.00 am	20.25 ± 0.75	72.00 ± 2.0	–	–	21.00 ± 0	70.5 ± 1.5	–	–	20.25 ± 0.75	72.00 ± 2.0	–	–
6.30 am	20.50 ± 0.5	71.00 ± 1.0	2.5 ± 0.5	1.00 ± 0	23.26 ± 1.08	69.0 ± 1.0	1.00 ± 0.81	0.66 ± 0.47	20.50 ± 0.5	71.00 ± 1.0	2.0 ± 1.0	0.66 ± 0.47
7.00 am	22.00 ± 1.0	69.50 ± 0.5	5.0 ± 1.0	2.88 ± 1.86	23.76 ± 1.60	67.5 ± 0.5	2.00 ± 0	1.00 ± 0.4	22.00 ± 1.0	69.50 ± 0.5	3.5 ± 1.5	1.33 ± 0.47
7.30 am	23.00 ± 0	68.00 ± 0	6.0 ± 2.0	3.33 ± 0.94	24.63 ± 1.32	67.0 ± 1.0	1.66 ± 0.47	1.33 ± 0.47	22.50 ± 0.5	68.00 ± 0	5.5 ± 2.5	2.33 ± 0.47
8.00 am	23.00 ± 0.5	66.50 ± 0.5	12.0 ± 2.0	4.00 ± 0.8	25.80 ± 1.06	62.0 ± 0	3.00 ± 0.81	2.00 ± 0.81	23.00 ± 0.5	66.50 ± 0.5	8.0 ± 4.0	3.00 ± 0.81
8.30 am	24.00 ± 1.0	63.50 ± 1.5	18.0 ± 2.0	5.33 ± 0.47	26.80 ± 0.58	59.0 ± 1.0	3.00 ± 1.41	2.50 ± 0.5	24.00 ± 1.0	63.50 ± 1.5	14.5 ± 5.5	4.33 ± 0.47
9.00 am	24.40 ± 1.2	60.50 ± 0.5	29.0 ± 3.0	7.00 ± 0.81	27.33 ± 0.47	63.0 ± 1.0	7.66 ± 3.68	5.00 ± 0.81	24.40 ± 1.2	60.50 ± 0.5	25.5 ± 2.5	5.83 ± 1.67
9.30 am	25.00 ± 1.0	59.00 ± 1.0	43.0 ± 6.0	8.33 ± 0.47	28.13 ± 0.18	61.0 ± 1.0	6.66 ± 1.69	4.33 ± 0.47	25.00 ± 1.0	59.00 ± 1.0	41.5 ± 2.5	8.00 ± 0.81
10.00 am	26.00 ± 1.0	57.50 ± 1.5	39.0 ± 2.0	8.00 ± 1.41	29.06 ± 0.41	56.0 ± 1.0	5.33 ± 1.69	4.00 ± 0	26.00 ± 1.0	57.50 ± 2.0	36.0 ± 0	8.33 ± 0.47
10.30 am	26.45 ± 1.05	55.50 ± 1.5	36.0 ± 2.0	8.33 ± 0.94	30.16 ± 0.84	51.0 ± 0	3.33 ± 0.94	2.00 ± 0.81	26.45 ± 1.05	55.50 ± 1.5	29.0 ± 1.0	6.33 ± 0.47
11.00 am	27.00 ± 1.0	53.25 ± 0.75	28.0 ± 2.0	5.33 ± 1.24	30.53 ± 1.03	46.5 ± 0.5	2.33 ± 0.94	1.33 ± 0.47	27.00 ± 1.0	53.25 ± 0.75	20.5 ± 0.5	5.66 ± 0.47
11.30 am	27.60 ± 1.0	51.75 ± 0.75	21.0 ± 3.0	4.00 ± 0.81	31.50 ± 1.08	43.0 ± 1.0	1.50 ± 0.5	1.33 ± 0.47	27.55 ± 1.05	51.75 ± 0.75	11.0 ± 0	3.66 ± 0.47
12.00 noon	28.10 ± 0.9	49.50 ± 1.5	11.0 ± 1.0	2.33 ± 1.24	32.33 ± 1.69	40.0 ± 0	1.00 ± 0	1.00 ± 0	28.10 ± 0.9	49.50 ± 1.5	4.0 ± 0	2.00 ± 0.81
12.30 pm	29.50 ± 1.5	47.50 ± 1.5	6.5 ± 0.5	1.33 ± 1.24	32.66 ± 1.74	40.0 ± 0	–	–	29.50 ± 1.5	47.50 ± 1.5	–	–
1.00 pm	29.75 ± 1.25	46.50 ± 1.5	–	–	33.06 ± 1.91	40.0 ± 0	–	–	29.80 ± 1.6	46.50 ± 1.5	–	–

Name of species and period of study (spanning header over all species columns)

Table 3. Floret opeing and bee visitation in *Bambusa*

Time	*Bambusa bambos* May–June 1998				*Bambusa vulgaris* December 1997–May 1998				*Bambusa* sp. January–April 1996			
	Temperature °C	Relative humidity %	No. of florets opened	No. of bees visited/floret	Temperature °C	Relative humidity %	No. of florets opened	No. of bees visited/floret	Temperature °C	Relative humidity %	No. of florets opened	No. of bees visited/floret
6.00 am	–	–	–	–	21.00 ± 0.81	89.25 ± 0.69	–	–	19.40 ± 0.6	83.50 ± 0.5	–	–
6.30 am	23.90 ± 0.1	68.00 ± 2.0	5.00 ± 3.0	1.33 ± 0.47	22.00 ± 0.81	89.00 ± 0.81	12.00 ± 0.81	1.33 ± 0.47	20.10 ± 1.1	81.00 ± 1.0	6.00 ± 3.0	–
7.00 am	24.50 ± 0.5	66.00 ± 0	14.00 ± 2.0	3.33 ± 0.47	23.50 ± 0.81	87.00 ± 0.4	28.00 ± 1.63	3.66 ± 0.47	21.35 ± 2.15	78.00 ± 4.0	8.33 ±6.12	0.66 ± 0. 47
7.30 am	25.00 ± 0	66.50 ± 1.5	21.33 ± 9.73	3.66 ± 0.47	24.00 ± 1.63	86.00 ± 0.40	27.00 ± 2.44	3.66 ± 0.47	21.40 ± 2.71	72.77 ± 9.05	9.66 ± 6.12	0.66 ± 0.57
8.00 am	25.10 ± 0.1	64.50 ± 2.5	26.33 ± 10.4	3.66 ± 0.47	24.50 ± 0.81	82.00 ± 0.81	20.00 ± 0.81	3.00 ± 0.81	22.13 ± 3.0	70.60 ± 10.0	12.66 ± 7.71	1.33 ± 0.47
8.30 am	25.65 ± 0.15	63.00 ± 4	20.33 ± 7.40	2.00 ± 0	25.00 ± 1.22	80.75 ± 0.47	18.00 ± 0.81	2.66 ± 0.47	24.50 ± 2.87	66.70 ± 10.5	16.00 ± 9.89	2.33 ± 0.47
9.00 am	26.35 ± 0.35	60.50 ± 3.5	19.00 ± 6.16	1.66 ± 0.47	25.20 ± 0.81	81.00 ± 0.4	10.66 ± 1.24	1.66 ± 0.47	26.33 ± 2.24	62.30 ± 11.3	17.00 ± 11.0	2.33 ± 0.47
9.30 am	26.65 ± 0.15	57.50 ± 5.5	15.33 ± 3.09	1.33 ± 0.47	26.00 ± 0	80.00 ± 0.81	9.00 ± 0.81	1.33 ± 0.47	28.83 ± 0.84	54.40 ± 12.2	18.33 ± 11.4	3.66 ± 0.47
10.00 am	26.90 ± 0.1	57.00 ± 5	8.33 ± 3.27	1.33 ± 0.47	26.00 ± 0.4	80.00 ± 1.63	6.00 ± 0.82	0.66 ± 0.47	29.50 ± 0.4	47.60 ± 13.2	14.00 ± 5.88	3.66 ± 0.47
10.30 am	27.40 ± 0.4	55.50 ± 4.5	5.33 ± 2.05	0.66 ± 0.47	27.00 ± 0.81	78.00 ± 0	3.00 ± 0	1.00 ± 0.81	30.33 ± 0.47	48.23 ± 11.2	14.33 ± 6.23	3.00 ± 0.81
11.00 am	28.00 ± 0.5	50.50 ± 1.5	4.00 ± 1.41	1.00 ± 0	27.33 ± 0.62	76.00 ± 0.81	–	–	31.16 ± 0.23	42.53 ± 13.1	9.66 ± 7.31	1.33 ± 0.47
11.30 am	28.50 ± 0.5	48.50 ± 2.5	3.00 ± 0.81	0.66 ± 0.47	28.50 ± 0.81	72.00 ± 0.81	–	–	31.66 ± 0.47	40.20 ± 12.6	5.33 ± 3.39	1.00 ± 0
12.00 noon	29.00 ± 0	47.50 ± 2.5	2.33 ± 0.47	0.33 ± 0.47	29.50 ± 0.4	66.33 ± 0.84	–	–	32.43 ± 0.66	38.33 ± 11.1	2.00 ± 1.0	0.66 ± 0.47
12.30 pm	29.10 ± 0.1	46.50 ± 3.5	1.00 ± 0.81	–	30.00 ± 0.4	63.33 ± 1.54	–	–	33.33 ± 0.94	37.33 ± 9.67	2.00 ± 0	–
1.00 pm	29.35 ± 0.15	45.75 ± 3.25	–	–	30.50 ± 0.4	61.40 ± 0.82	–	–	32.50 ± 1.5	41.00 ± 9.0	–	–
1.30 pm									31.00 ± 0	40.00 ± 8.0	–	–
2.00 pm									31.75 ± 1.25	39.50 ± 7.5	–	–
2.30 pm									31.75 ± 1.25	40.00 ± 6.0	–	–
3.00 pm									31.75 ± 1.25	42.00 ± 6.0	6.50 ± 2.5	–
3.30 pm									32.50 ± 0	43.50 ± 5.5	9.00 ± 2.0	1.00 ± 0
4.00 pm									32.00 ± 0	47.00 ± 7.0	10.00 ± 3.0	1.66 ± 0.47
4.30 pm									31.50 ± 0.5	49.00 ± 5.0	14.50 ± 2.5	2.33 ± 0.47
5.00 pm									31.00 ± 0	51.00 ± 5.0	15.00 ± 1.0	2.33 ± 0.47
5.30 pm									30.00 ± 0	53.00 ± 5.0	8.00 ± 0	1.00 ± 0
6.00 pm									29.00 ± 0	54.50 ± 4.5	3.00 ± 0	1.00 ± 0

Name of species and period of study (spanning header over all species columns)

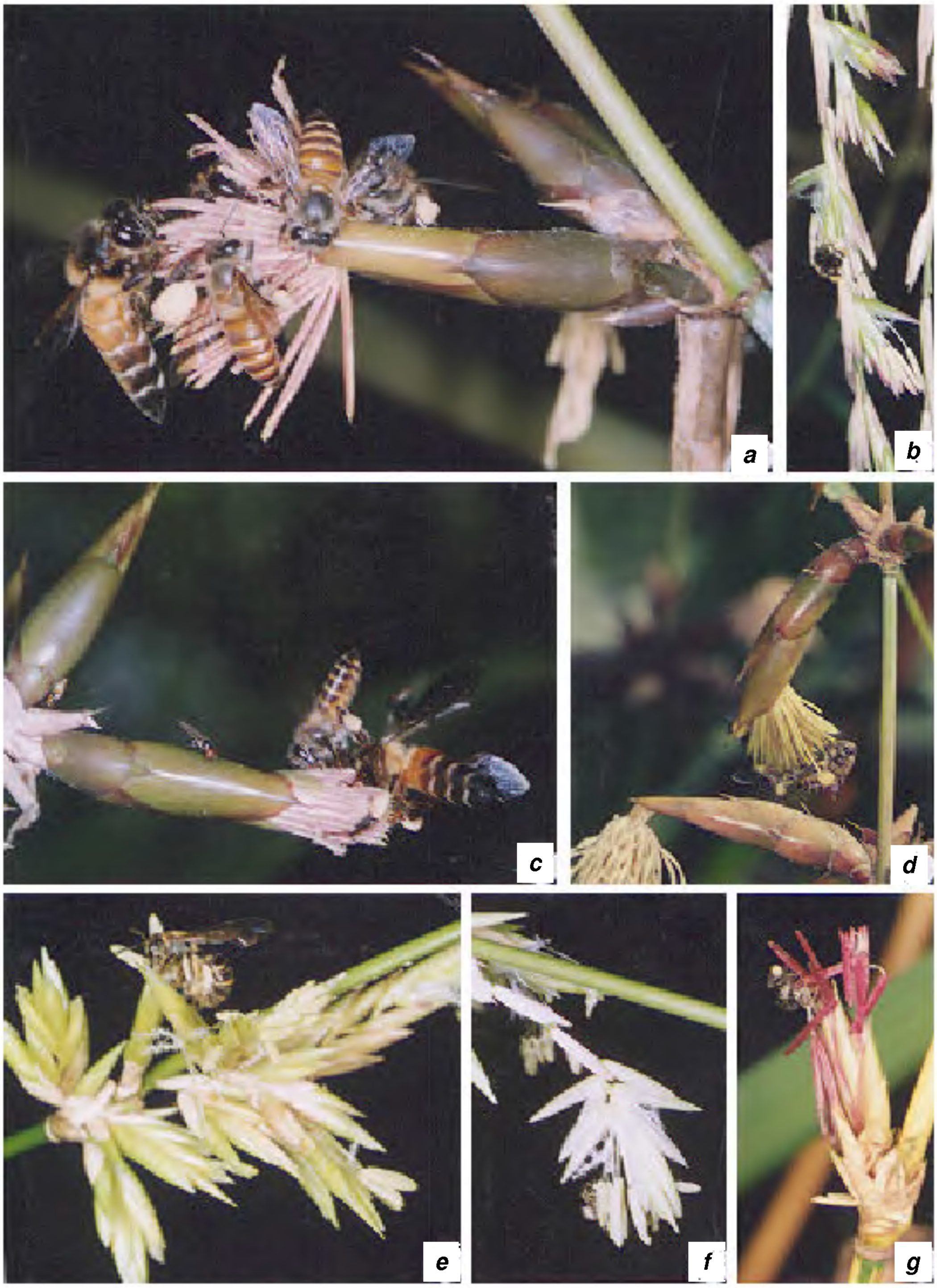

Figure 1 ***a–g*****.** Bee visits on the spikelets of various bamboo species. ***a***, ***c***, *Apis dorsata* (larger bee) and *A. cerana* (smaller bee) on *Ochlandra travancorica;* ***a***, peak foraging; ***c***, moderate foraging. ***b***, *Halictus* sp. on *Bambusa* sp.; ***d***, *A. cerana* on *O. ebracteata*; ***e***, *A. cerana on B. bambos;* ***f***, *Halictus* sp. on *B. bambos;* ***g***, *Trigona biroi* on *B. vulgaris.* Note the tubular florets in *Ochlandra* (***a***, ***c***, ***d***) and *B. vulgaris* (***g***), and open florets in *Bambusa* (***b***, ***e***, ***f***).

droop downwards on exsertion. In most cases the inflorescence itself is in a drooping state. Because of this drooping nature, the bees resting on anthers can avoid visiting the stigmas. If they, by chance, enter into the widely-opened spikelets, transfer of pollen can occur. It is, therefore, reasonable to think that in such species at least, bees have a role in pollination.

It is observed that wind-pollinated taxa have flowers in which the sexes do not co-occur[2]. The present and earlier studies[13,14] in *Ochlandra* spp and *Dendrocalamus strictus,*

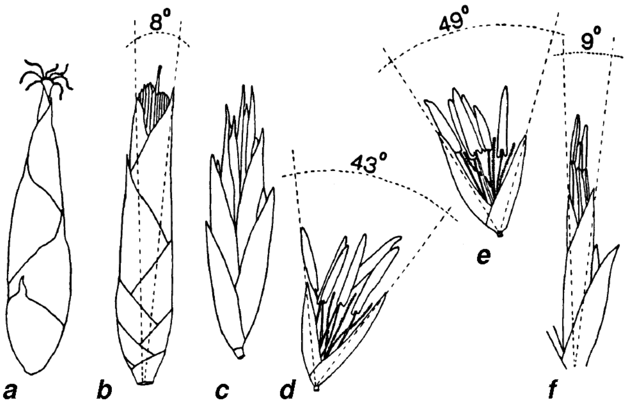

Figure 2 *a–f*. Diagrammatic representation of spikelets of *Ochlandra* (***a***, ***b***) and *Bambusa* (*c–f*) showing the angle of opening. ***a***, *Ochlandra* sp. beginning of female stage; ***b***, peeping-out stage of anthers; ***c***, spikelet of *Bambusa* sp.; ***d–f***, floret opening in *Bambusa*, ***d***, *B. bambos*; ***e***, *Bambusa* sp. and ***f***, *B. vulgaris*.

both taxa having dichogamous flowers, confirm this view. However in *Bambusa* spp, where the two sexes mature simultaneously, the above observation is not acceptable. Being homogamous, these taxa may have a high rate of self-pollination[2], as inferred in the case of *B. bambos* (= *B. arundinacea*)[21] or perhaps, *Bambusa* spp represent an intermediate condition among woody bamboos where wind pollination and insect pollination co-exist.

The present study is in agreement with the division of the bamboos into two groups[22]: (1) the species in which the androecium and gynoecium mature at the same time, i.e. *Bambusa*-type, and (2) the protogynous species in which the gynoecium matures prior to the androecium, i.e. *Dendrocalamus*-type. We propose a further grouping based on floret opening in the *Bambusa* type, i.e. (1) species in which floral glumes are widely separated (e.g. *B. bambos, Bambusa* sp.), and (2) those in which floral glumes are not widely separated as in *B. vulgaris*. We also propose to refer to these as *open florets* in the former and *tubular* (*closed*) *florets* in the latter case.

The present study poses a few interesting questions also. Why is it that the bees do not visit the stigmas? Is there any chemical or physical deterrent which prevents these bees from such visits? Further studies are required in these directions and also to confirm the role of bees in bamboo pollination and the suspected co-existence of self-pollination, anemophily and hymenopterophily in taxa such as *Bambusa*.

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Erratum

Induction of *in vivo* somatic embryos from tea (*Camellia sinensis*) cotyledons

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Figure 2 *b* of microtome is of Kangra Jat origin of somatic embryo but not UPASI-9 and the same did not occur in moist sterile and sand. We regret the error.

Authors